

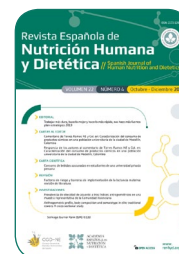
Revista Española de Nutrición Humana y Dietética

Spanish Journal of Human Nutrition and Dietetics



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RESEARCH ARTICLE

Anthropometric profile, body composition and somatotype in elite traditional rowers: A cross-sectional study

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Received: 17/05/2018; accepted: 24/09/2018; published: 20/10/2018.

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KEYWORDS

Water Sports;
Athletes;
Rowing Athletes;
Anthropometry;
Body Composition;
Somatotypes.

ABSTRACT

Introduction: Given the importance of body composition in sports performance, it is vital to have references of elite athletes which serve as a guide when it comes to overseeing diet and training. The aim of this study was to describe the anthropometric values of an elite team of traditional rowers in order to build an anthropometric profile in this sport.

Material and Methods: A cross-sectional design with twenty elite, male traditional rowers aged at 29.3 (3.6) years reported to the laboratory on a single day at the start of the competitive season. Height, wingspan, body mass, 8 skinfolds, 2 bone diameters and 6 perimeters were measured by the same internationally certified anthropometrist. Anthropometric measurements were taken following the International Society of Advancement of Kinanthropometry (ISAK) protocol. Fat mass was calculated using different equations for athletes and muscle mass using the Lee equation. For the somatotype components, the Carter and Heath equation was applied.

Results: Elite traditional rowers had a wingspan of 189 (5.8) cm, body fat percentage of 8.0 (1.2)% (Carter), 8.0 (1.8)% (Withers), 7.0 (1.2)% (Yuhasz), and 10.9 (1.1)% (Faulkner). Muscle mass was 43.3 (2.4)% (Lee). The somatotype was endo-mesomorphic with endomorphy values of 3.5 (0.4), mesomorphy 4.7 (0.6) and ectomorphy 2.4 (3.5).

Conclusions: These results suggest that wingspan seems to be of great importance for elite traditional rowers; while average height may not be as important for performance as wingspan. Meanwhile, reducing body fat percentage is likely to be beneficial in order to achieve elite rowing status.

PALABRAS CLAVE

Deportes Acuáticos;
 Atletas;
 Atletas de Remo;
 Antropometría;
 Composición Corporal;
 Somatotipo.

➤ **Perfil antropométrico, composición corporal y somatotipo de remeros tradicionales de élite: Estudio transversal**

RESUMEN

Introducción: Debido a la importancia que la composición corporal tiene en el rendimiento deportivo es necesario disponer de referencias de deportistas de élite que sirvan de guía a la hora de orientar la dieta y el entrenamiento.

Material y Métodos: El estudio fue diseñado como un estudio transversal que incluyó a veinte remeros tradicionales de élite de 29,3 (3,6) años de edad que acudieron al laboratorio un solo día al comienzo del período competitivo. La altura, envergadura, masa corporal, 8 pliegues cutáneos, 2 diámetros óseos y 6 perímetros fueron determinados por el mismo antropometrista internacionalmente certificado. Las medidas fueron recogidas siguiendo el protocolo de la Sociedad Internacional para el avance de la Cineantropometría (ISAK). La masa grasa se calculó utilizando diferentes ecuaciones para deportistas, y la masa muscular mediante la ecuación de Lee. Los componentes del somatotipo fueron estimados mediante la ecuación Carter y Heath.

Resultados: Se observó que los remeros de élite tenían una envergadura de 189 (5,8) cm, un porcentaje de grasa corporal de 8,0 (1,2)% según las ecuaciones de Carter, 8,0 (1,8)% de Withers; 7,0 (1,2)% de Yuhasz, y 10,9 (1,1)% de Faulkner. La masa muscular fue de 43,3 (2,4)% según la ecuación de Lee. El somatotipo fue endomesomorfo con valores de endomorfia de 3,5 (0,4), mesomorfia de 4,7 (0,6) y ectomorfia de 2,4 (3,5).

Conclusiones: Estos resultados sugieren que la envergadura parece ser de gran importancia para los remeros de élite, mientras que la altura promedio puede no ser tan importante para el rendimiento. Por su parte, reducir el porcentaje de grasa corporal es probablemente beneficioso para lograr un buen rendimiento en este deporte.

CITATION

León-Guereño P, Urdampilleta A, Zourdos MC, Mielgo-Ayuso J. Anthropometric profile, body composition and somatotype in elite traditional rowers: A cross-sectional study. Rev Esp Nutr Hum Diet. 2018; 22(4): 279-86. doi: 10.14306/renhyd.22.4.605

INTRODUCTION

The sport of rowing can be divided into two subtypes, both of which require specific physiological characteristics, and have significant performance differences. The first type, Olympic rowing, is performed on calm and reservoir waters over a distance of 2,000m. In contrast, traditional rowing occurs on rough sea waters with 13 rowers per crew and a coxswain^{1,2}, whose goal is to complete a 5,556m (3 nautical miles) regatta in the shortest possible time. In both types of rowing data has revealed glycolysis to be the primary energy system in use^{1,2}.

During a traditional rowing regatta simulation, average power output has been reported to be 250 (7) W, while rowers are simultaneously competing at 110.26 (4.48)%

above the individual anaerobic threshold³. In accordance, blood lactate concentrations have been reported to reach high levels following a race (10–18mmol/L)^{1,2}. However, post-race blood lactate concentration is position-dependent in that athletes closest to the stern of the boat (i.e. stroke seats) have higher concentrations of lactate³. Furthermore, an elite boat can reach an average speed of 4.63m/sec, which is achieved by a frequency of 36-40strokes/min throughout the course of a 20-minute regatta¹. Additionally, the drive time (blade submerged in the water), is about 1.50–1.66sec/stroke³, depending on the stroke style (i.e. primarily arms or back). Consequently, a rower's physical dimensions and anthropometrics must be taken into account since the natural physical demands of rowing performance are substantial. In fact, anthropometric parameters have been correlated with performance in elite sport, and anthropometric characteristics have been associated with

Olympic rowing performance outcomes⁴. For instance, data has shown that a taller rower with high lean body mass may be advantageous due to a longer lever arm (i.e. force arm > resistance arm)^{3,4}, resulting in greater power output per stroke.

Body composition (BC), especially a rower's fat mass (FM), fat-free mass (FFM) and muscle mass (MM), may also affect performance^{5,6}. Excessive FM in a rower, in particular, would act as deadweight, and would have adverse effects on speed, resulting in a diminished ability to accelerate⁷. Moreover, it is well established that greater FFM and MM in a high-intensity athlete leads to increased strength and endurance; thus, performance improvement⁸. Moreover, anthropometric characteristics in junior age groups affect their long-term careers, underlining the relevance of anthropometric assessments and their consideration for talent identification and development programs in rowing⁹.

There are many sports possessing anthropometric profiles and defined body compositions such as volleyball¹⁰ and basketball¹¹, enabling athletes to opt for maximum performance. Along these lines, Pons *et al.*, have defined the anthropometric characteristics, body compositions and somatotypes of Spanish athletes from different specialties who have participated in the Olympics over the last 25 years¹². Hence, references for 24 sports are available in Spain with their specialties or categories, including Olympic rowing, enabling nutritionists and trainers to guide both diet and training so as to achieve the body composition allowing athletes to attain maximum performance. However, there is no study examining the anthropometrical profile of traditional rowers in an elite boat –and its relationship to performance– which allows coaches and sport scientists to better understand the physical profile of elite rowers, and formulate appropriate training strategies¹³. Therefore, the aims of this study are to describe elite traditional rowers' anthropometric characteristics (BC, FM, MM, and somatotype) in order to establish reference values within this population of rowers.

MATERIAL AND METHODS

Sample

The “*asociación de clubs de traineras (ACT)*” league consists of 12 boats, each with 20 rowers. In this respect, for the cross-sectional design of this study, data was collected from the twenty male traditional rowers (29.3 (3.6) years) in the first division's winning crew, considered the best team over the past 5 years, participating in this study (experience ≥ 6

years). They all performed the same supervised training 7 days a week for 2–3h/day. Every rower received both oral and written information regarding the research objectives, and all rowers provided written consent prior to participation. This study met the requirements of the II Declaration of Helsinki and was approved by the UPV-EHU ethics committee.

Experimental Design

In order to undergo the anthropometric measurements, the participants reported to the laboratory on a single day at the beginning of the competitive season. All anthropometric measurements were performed in compliance with the International Society of Advancement of Kinanthropometry (ISAK) protocol¹⁴ by the same international level-2 certified anthropometrist.

Height (cm) was measured using a SECA 220 measuring rod (Hamburg, Germany), with precision to within 1mm. Body Mass (BM) (kg) was measured using SECA 700 scales to within 0.1kg. Body Mass Index (BMI) was calculated using the $\text{BM}/\text{height}^2$ (kg/m^2) equation. Skinfolds (mm) (tricipital, bicipital, abdominal, supraillium, subscapular, iliac crest, front thigh, and calf) were analyzed using the Holtain skinfold caliper, with precision to within 0.2mm. In order to obtain several observations, the sum of 4 ($\Sigma 4\text{SF}$), 6 ($\Sigma 6\text{SF}$) and 8 ($\Sigma 8\text{SF}$) skinfolds (mm) were examined following validated procedures¹². Muscle perimeters (cm) (arm, contracted arm, waist, hips, thigh and calf muscles) were assessed using a metal, non-extensible tape (Lufkin) with precision to within 1mm. All perimeters were corrected via skinfolds by using the following formula: corrected perimeter = perimeter – ($\pi \times$ skinfold area). Such corrections provide the best information regarding musculoskeletal size in each body zone¹⁵. Humeral and femoral diameters were measured with a Holtain pachymeter, accurate to within 1mm.

FM and body fat percentage (BF%) were calculated using the Carter, Withers, Yuhasz and Faulkner equations as they have already been recommended for athletes in the Spanish Kinanthropometry Group (GREC)^{16,17}. Similarly, MM and MM% were calculated using the Lee equation^{16,17}. The Carter and Heath equation¹⁸ was used to obtain somatotype values.

Statistical Analysis

All anthropometric data is presented as mean (standard deviation). The minimum and maximum values of the anthropometric measurements, BC and somatotype were calculated similarly. Statistical data analysis was carried out using the SPSS software package for Windows, version 21.0. (SPSS, Inc., Chicago, IL, USA).

RESULTS

The descriptive data for all variables is displayed in 2 tables. Specifically, Table 1 shows the basic anthropometric values, such as BM (80.4 (6.3) kg; range: 71.0–88.5kg), height (182.5 (5.2) cm; range: 174.0–190.5cm), and BMI (24.1

(1.3) kg/m²; range: 21.6–27.3kg/m²). Special attention has been paid to wingspan values (188.6 (5.8) cm; range: 178.0–198.0cm) due to their association with performance in traditional rowing. Similarly, Table 1 displays all perimeters, some of which have been corrected by their respective skinfolds in order to calculate muscle mass using the Lee equation; such as corrected arm perimeter (28.4

Table 1. Basic anthropometric parameters, perimeters, skinfolds and bony diameters (n=20).

	Mean (SD)	Maximum	Minimum
BASIC ANTHROPOMETRIC PARAMETERS			
Body Mass (kg)	80.4 (6.3)	88.5	71.0
Height (cm)	182.5 (5.2)	190.5	174.0
Wingspan (cm)	188.6 (5.8)	198.0	178.0
BMI (kg/m ²)	24.1 (1.3)	27.3	21.6
PERIMETERS (cm)			
Relaxed arm	30.8 (1.6)	33.9	28.1
Flexed arm	34.7 (1.7)	38.0	31.9
Waist	80.6 (3.3)	86.3	71.8
Hip	96.0 (4.6)	102.0	84.5
Thigh	53.8 (2.5)	58.0	48.1
Calf	38.8 (2.5)	43.0	33.1
Corrected arm perimeter	28.4 (1.6)	31.3	26.1
Corrected waist perimeter	77.1 (3.2)	68.8	82.5
Corrected thigh perimeter	50.4 (2.6)	56.0	45.6
Corrected calf perimeter	36.6 (2.7)	41.6	31.8
SKINFOLDS (mm)			
Biceps	3.4 (0.6)	4.35	2.5
Triceps	7.5 (1.3)	9.5	5.8
Subscapular	9.0 (1.6)	12.6	5.8
Abdominal	11.1 (3.7)	20.6	4.5
Suprailium (Iliac crest)	6.1 (1.9)	12.3	3.5
Iliac crest	12.5 (5.2)	27.6	5.1
Front thigh	10.9 (3.5)	17.2	5.3
Calf	6.9 (3.4)	15.5	3.4
Σ4SF	33.7 (7.1)	53.0	20.4
Σ6SF	51.5 (11.4)	72.8	31.5
Σ8SF	67.3 (15.6)	99.2	42.1
DIAMETERS (cm)			
Humerus	7.1 (0.4)	7.6	6.2
Femur	10.3 (0.5)	11.2	9.4

BMI: Body Mass Index; **Σ4SF:** Sum of four skinfolds; **Σ6SF:** Sum of six skinfolds; **Σ8SF:** Sum of eight skinfolds.

(1.6) cm; range: 26.1–31.3cm), corrected thigh perimeter (50.4 (2.6) cm; range: 45.6–56.0cm) and corrected calf perimeter (36.6 (2.6) cm; range: 31.8–41.6cm). Moreover, Table 1 shows all skinfolds and the sum of them. Thus, the $\Sigma 4SF$ was 33.7 (7.1) mm (range: 20.4–53.0mm), $\Sigma 6SF$ was 51.5 (11.4) mm (range: 31.5–72.8mm) and $\Sigma 8SF$ was 67.3 (15.6) mm (range: 42.1–99.2mm). Finally, Table 1 presents bone diameters, where the humerus was 7.1 (0.4) (range: 6.2–7.6) and femur was 10.3 (0.5) (range: 9.4–11.2).

Table 2 presents BF%, FM, MM%, and MM (kg) as calculated using different specific equations and the somatotype. BF% was thereby between 8.0 (1.2)% using the Carter equation, 10.9 (1.1)% using the Faulkner equation, 8.6 (1.1)% using the Yuhasz equation and 9.9 (2.0)% according to the Withers equation. Table 2 also shows MM% using the Lee equation (43.3 (2.4)%; range: 39.4–47.8%). Regarding somatotype, the somatotype values were: endomorphy (3.5 (0.4); range: 2.7–4.4), mesomorphy (4.7 (0.6); range: 3.4–5.7), ectomorphy 2.4 (0.6); range: 0.8–3.5). This data revealed that elite traditional rowers can be classified as endo-mesomorphs (Figure 1).

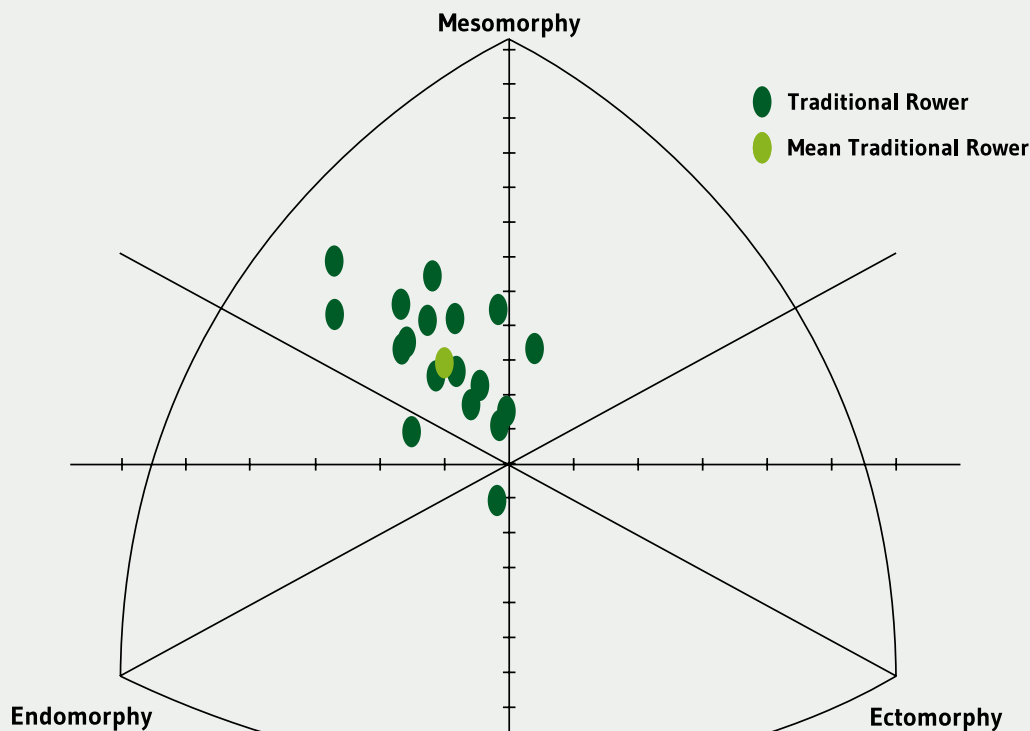
DISCUSSION

This is the first study analyzing the anthropometric characteristics of elite traditional rowers. Firstly, a mean height of 182cm and a mean BM of 80.4kg in elite rowers were observed. The present findings are similar to those of Mujika *et al.*¹⁹, who reported an average height of 186cm and BM of 80.4kg in 14 elite rowers. Similarly, Izquierdo-Gabarren *et al.*¹ found 24 elite rowers to have the following measurements: height=182cm and BM=82.4kg compared to 22 amateurs with measurements of: height=182.1m and BM=80.2kg. Interestingly, a wide range of height and BM was observed: 178–198cm and 71–88.5kg respectively, suggesting that different anthropometric compositions may be needed within specific crew positions. Specifically, hydrodynamic reasons²⁰ may lead to varying height and BM requirements among the 13 rowers in a crew in order to balance the boat through rough seas¹. In Olympic rowers, however, data has reported wider ranges for height (187.2–194cm) and BM (85.8–97.2kg)^{21–24} than the present

Table 2. Participants' body composition and somatotype (n=20).

	Mean (SD)	Maximum	Minimum
BODY COMPOSITION			
Carter body fat (%)	8.0 (1.2)	10.2	5.9
Carter FM (kg)	6.4 (1.1)	8.6	4.3
Withers body fat (%)	9.9 (2.0)	13.4	6.1
Withers FM (kg)	8.0 (1.8)	11.3	4.5
Yuhasz body fat (%)	8.6 (1.1)	10.7	6.7
Yuhasz FM (kg)	7.0 (1.2)	9.1	4.9
Faulkner body fat (%)	10.9 (1.1)	13.9	8.9
Faulkner FM (kg)	8.8 (1.2)	12.1	6.5
Lee MM (%)	43.3 (2.4)	47.8	39.4
Lee MM (kg)	34.7 (3.1)	41.4	29.5
SOMATOTYPE			
Endomorphy	3.5 (0.4)	4.4	2.7
Mesomorphy	4.7 (0.6)	5.7	3.4
Ectomorphy	2.4 (0.6)	3.5	0.8

FFM: Fat-Free Mass; **FM:** Fat Mass.

Figure 1. Participants and mean somatochart (n=20).

investigation pertaining to traditional rowers. These higher values in Olympic rowers have also been a positive indicator of performance^{25–27}. Hence, traditional rowers may not need as much height and BM as Olympic rowers possibly due to the fact that traditional rowing relies more on the arms and less on torso bending and leg extension compared to Olympic rowing²⁰.

Moreover, since the arms are a primary factor throughout the traditional rowing stroke, it is essential to assess wingspan as it is paramount to anthropometric parameters during the course of each stroke²⁰. An average wingspan of 189cm was now observed, representing a mean difference of 7cm compared to height. In contrast, data has reported that Olympic rowers have longer wingspans (193.4–200.6cm)^{22,23,27}, which represents only a 4–6cm difference in relation to height. It could be speculated that the legs may not fully complete flexion and extension throughout the course of each stroke in traditional rowing, thus allowing for a shorter wingspan compared to Olympic rowing despite there being greater reliance on the arms.

A 28.4cm perimeter of the corrected relaxed arm and a 36.6cm calf perimeter (Table 1) were observed, which is lower than the corrected values reported by Kerr *et al.*²¹ (arm: 31.1cm; calf: 37.3cm) in Olympic rowers and non-corrected values reported by Mikulic^{22,23} (arm: 33.9–35cm; calf: 40.1–40.3cm). Consequently, the data reveals that traditional rowers do not possess muscle mass to the same extent as Olympic rowers, which may be advantageous owing to the significant muscular endurance requirements of traditional rowing. Similarly, and in agreement with Kerr *et al.*²¹, a small hip perimeter (96cm) was observed, which is common in both types of rowing due to the use of narrow boats. The long, narrow shape of the hull is designed to minimize forward motion drag²¹, and a small hip perimeter allows the athlete to fit suitably into this narrow shape.

Regarding BF%, previous research has observed a higher BF% (12.3%) in elite traditional rowers¹ than any of the values obtained in this study. Additionally, Mikulic reported a 15.9% BF% in 14 international Olympic rowers and 13.2% BF% in 25 elite Croatian rowers²³, both of which are higher than the

present values. Moreover, this value can change during the season^{28,29}. Along the same lines, Spanish Olympic rowers, depending on their category (lightweight or heavyweight), presented a BF% of 11.1 (1.1)% (Faulkner), 6.9 (1.2)% (Yuhasz), 11.9 (1.8)% (Faulkner) and 14.7 (3.2)% (Yuhasz) respectively¹². However, it is difficult to compare these values as several body composition equations are often used, yielding an array of results (Table 1). In accordance with other authors¹⁶, the sum of skinfolds is used to analyze and establish normative data and to compare studies. In fact, Kerr *et al.*²¹ presented a Σ 8SF from 140 elite rowers during the Sydney 2000 Olympics, resulting in a mean value of 65.3mm, which is indeed comparable to the present Σ 8SF values of 67.3mm. Ultimately, a low BF% is desirable for rowers because, especially in longer distances²⁴, an excess of FM can affect propulsion negatively, causing diminished speed and acceleration, which results in increased energy demand³⁰.

With regard to muscle mass, there are indications that this is responsible for providing power and speed to the rowers' rowing motion. In this respect, there are no references with which to draw comparisons since many authors include fat-free mass, which not only includes muscle but also bones, organs, minerals, blood, etc., leading to a possible overestimation of the amount of muscle mass¹⁶. However, somatotype provides information regarding the general physical shape of an athlete, which provides insight into the general desired shape for specific sports¹⁶. Somatotype analysis in the current study revealed that elite traditional rowers can be categorized as endo-mesomorphic (Figure 1), in that the rowers possess only moderate musculoskeletal development with moderate relative adiposity¹⁶. In contrast, Kerr *et al.* demonstrated a somatotype classification of ecto-mesomorphs (moderate musculoskeletal development, and low subcutaneous adiposity) in Olympic rowers²¹. Although the endomorph value in the present study is much higher than in the previous study²¹, this is more likely due to the specific sites where somatotype is calculated; in that it is probable these sites are leaner in Olympic rowers vs. traditional rowers due to the greater strength and lower endurance demands of Olympic rowing. In support of this hypothesis, the Σ 8SF was similar in the two investigations; therefore, even though somatotype is a valuable tool, it may overestimate body composition in the present population owing to the body sites from which somatotype is obtained.

The main limitation here is that the sample cannot be regarded as representative of the ACT because a specific sample calculation was not performed. However, it is important to indicate that the club studied was champion of the ACT league as well as the winner of "La bandera de la Concha"; the competition outside the most important rowing league.

Therefore, the present values could be used as normative values for elite traditional rowers to structure training in order to achieve a desired anthropometric composition.

CONCLUSIONS

Wingspan seems to be of great importance for elite traditional rowers; the height may not be as important for performance as wingspan, and a low body fat percentage is likely to be beneficial in order to achieve elite rowing status. Ultimately, the elite traditional rower's somatotype is endo-mesomorph, suggesting that muscle endurance is a prominent factor in traditional rowing and, considering its importance in relation to training periodization, training programs should be designed accordingly. However, caution should be taken when interpreting the present results, as more research is needed to determine the exact relationships between the anthropometric profile and specific performance outcomes in elite traditional rowers.

ACKNOWLEDGMENTS

The authors wish to thank all the volunteers who participated in this study. Moreover, authors also want to thank the ErikaEsport Center for allowing us to use their facilities in data collection.

FUNDING

The authors declare that no funding has been received for this study.

COMPETING INTERESTS

Authors state that there are no conflicts of interest in preparing the manuscript.

REFERENCES

- (1) González-Aramendi JM, Santisteban J, Ainz F. Valoración funcional en laboratorio del remero de banco fijo. Arch Med Deporte. 1996; XIII(52): 99-105.

- (2) Badiola JJ, Aparicio AC, Fernandez-García B. Cinética del lactato y variables fisiológicas relacionadas con el rendimiento en una regata de traineras. *Infocoos*. 2001; VI(1): 36-48.
- (3) Cosgrove MJ, Wilson J, Watt D, Grant SF. The relationship between selected physiological variables of rowers and rowing performance as determined by a 2000 m ergometer test. *J Sports Sci*. 1999; 17(11): 845-52.
- (4) Shephard RJ. Science and medicine of rowing: A review. *J Sports Sci*. 1998; 16(7): 603-20.
- (5) Akça F. Prediction of rowing ergometer performance from functional anaerobic power, strength and anthropometric components. *J Hum Kinet*. 2014; 41: 133-42.
- (6) Penichet-Tomás A, Pueo B. Performance conditional factors in rowing (Factores condicionales de rendimiento en remo). *Retos*. 2017; 32: 238-40.
- (7) Mielgo-Ayuso J, Maroto-Sánchez B, Luzardo-Socorro R, Palacios G, Palacios Gil-Antuñano N, González-Gross M, et al. Evaluation of nutritional status and energy expenditure in athletes. *Nutr Hosp*. 2015; 31(Suppl 3): 227-36.
- (8) Mielgo-Ayuso J, Zourdos MC, Calleja-González J, Urdampilleta A, Ostojic SM. Dietary intake habits and controlled training on body composition and strength in elite female volleyball players during the season. *Appl Physiol Nutr Metab*. 2015; 40(8): 827-34.
- (9) Winkert K, Steinacker JM, Machus K, Dreyhaupt J, Treff G. Anthropometric profiles are associated with long-term career attainment in elite junior rowers: A retrospective analysis covering 23 years. *Eur J Sport Sci*. 2018.
- (10) Lidor R, Ziv G. Physical and physiological attributes of female volleyball players-a review. *J Strength Cond Res*. 2010; 24(7): 1963-73.
- (11) Ziv G, Lidor R. Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. *Sports Med*. 2009; 39(7): 547-68.
- (12) Pons V, Riera J, Galilea PA, Drobnic F, Banquells M, Ruiz O. Características antropométricas, composición corporal y somatotipo por deportes. Datos de referencia del CAR de San Cugat, 1989-2013. *Apunts Med Esport*. 2015; 50(186): 65-72.
- (13) Adhikari A, McNeely E. Anthropometric Characteristic, Somatotype and Body Composition of Canadian Female Rowers. *Am J Sports Sci*. 2015; 3(3): 61.
- (14) International Society for the Advancement of Kinanthropometry, editor. *International Standards for Anthropometric Assessment*. Glasgow: ISAK; 2016.
- (15) Mielgo-Ayuso J, Calleja-González J, Clemente-Suárez VJ, Zourdos MC. Influence of anthropometric profile on physical performance in elite female volleyballers in relation to playing position. *Nutr Hosp*. 2014; 31(2): 849-57.
- (16) Cabañas MD, Esparza F. *Compendio de cineantropometría*. Madrid: CTO Editorial; 2009.
- (17) Alvero Cruz JR, Cabañas MD, Herrero de Lucas A, Martínez Rianza L, Moreno Pascual C, Porta Manzanillo J, et al. Protocolo de valoración de la composición corporal para el reconocimiento médico-deportivo. Documento de consenso del grupo español de cineantropometría de la federación española de medicina del deporte. *Arch Med Deporte*. 2009; XXVI(131): 166-79.
- (18) Carter JEL, Heath BH. *Somatotyping-development and applications*. Cambridge [England]; New York: Cambridge University Press; 1990.
- (19) Mujika I, de Txabarri RG, Maldonado-Martín S, Pyne DB. Warm-up intensity and duration's effect on traditional rowing time-trial performance. *Int J Sports Physiol Perform*. 2012; 7(2): 186-8.
- (20) Baudouin A, Hawkins D. A biomechanical review of factors affecting rowing performance. *Br J Sports Med*. 2002; 36(6): 396-402.
- (21) Kerr DA, Ross WD, Norton K, Hume P, Kagawa M, Ackland TR. Olympic lightweight and open-class rowers possess distinctive physical and proportionality characteristics. *J Sports Sci*. 2007; 25(1): 43-53.
- (22) Mikulic P. Anthropometric and physiological profiles of rowers of varying ages and ranks. *Kinesiology*. 2008; 40(1): 80-8.
- (23) Mikulic P. Anthropometric and metabolic determinants of 6,000-m rowing ergometer performance in internationally competitive rowers. *J Strength Cond Res*. 2009; 23(6): 1851-7.
- (24) Ingham SA, Whyte GP, Jones K, Nevill AM. Determinants of 2,000 m rowing ergometer performance in elite rowers. *Eur J Appl Physiol*. 2002; 88(3): 243-6.
- (25) Bourgeois J, Claessens AL, Vrijens J, Philippaerts R, Van Renterghem B, Thomis M, et al. Anthropometric characteristics of elite male junior rowers. *Br J Sports Med*. 2000; 34(3): 213-7.
- (26) Bourgeois J, Claessens AL, Janssens M, Van Renterghem B, Loos R, Thomis M, et al. Anthropometric characteristics of elite female junior rowers. *J Sports Sci*. 2001; 19(3): 195-202.
- (27) Barrett RS, Manning JM. Relationships between rigging setup, anthropometry, physical capacity, rowing kinematics and rowing performance. *Sports Biomech*. 2004; 3(2): 221-35.
- (28) Young KC, Kendall KL, Patterson KM, Pandya PD, Fairman CM, Smith SW. Rowing performance, body composition, and bone mineral density outcomes in college-level rowers after a season of concurrent training. *Int J Sports Physiol Perform*. 2014; 9(6): 966-72.
- (29) Kuzuhara K, Katai K, Hojo T, Fujisawa Y, Kimura M, Yanagida Y, et al. Seasonal changes in anthropometric, physiological, nutritional, and performance factors in collegiate rowers. *J Strength Cond Res*. 2018.
- (30) Reilly T. Fitness assessment. In: T. Reilly, editor. *Science and Soccer* London: E & FN Spon; 2006. p. 25-50.